450-215/EO-1

NETWORKS AND MISSION SERVICES PROJECT

Detailed Mission Requirements (DMR) Document for the

New Millennium Program Earth Observing-1 (NMP/EO-1)

Review Copy (Issue 6)

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National Aeronautics and
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Goddard Space Flight Center
Greenbelt, Maryland

New Millennium Program Earth Observing- 1
(NMP/EO-1)
Detailed Mission Requirement (DMR)

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Table of Contents

Page

1.1 Mission Title & Responsible Organizations 1

1.2 General Mission Information 2

1.3 General Launch Information 13

1.4 Orbit/Trajectory 14

1.5 References 15

2.0 RF Summary 16

2.1 RF Link Properties 17

2.2 Networks 18

3.0 Testing and Training Summary 31

3.1 Integrated Testing 31

3.2 Integrated Simulations and Test Tools 33

3.3 Training 34

4.0 Mission Operation 35

5.0 Ground Communications and Data Transport 45

5.1 Table of Connectivity 48

6.0 Data Processing 50

7.0 Trajectory & Attitude Support 53

7.1 Attitude Determination and Control 53

7.2 Trajectory Design and Control 54

Table of Contents (continuation) <u>Page</u>

7.3 Orbit Determination, Acquisition Data, and Scheduling Data 55

7.4 Flight Dynamics Facility 57

Appendix A. Glossary 59

Distribution List 63

Section 1. General Information

1.1 Mission Title & Responsible Organizations

1.1.1 Title

The New Millennium Project Earth Observing-1 (EO-1)

1.1.2 Program Relationships

EO-1 is the first mission of the Earth Observing segment of the National Aeronautics and Space Administration (NASA) New Millennium Program.

1.1.3 Sponsoring/Approving Organization

The EO-1 Project Office (Code 426) is administered under the New Millennium Program, NASA Headquarters, and has overall responsibility for the project's development activities.

1.1.4 Responsibilities for Management, Project, Operations

The NMP EO-1 Project Office is located at the Goddard Space Flight Center (GSFC).

1.1.4.1 Project Roles

Program Office (Headquarters) - Mr. William Townsend, acting associate administrator for Mission to Planet Earth, has overall authority over the Earth Science Program.

New Millennium Program Manager (JPL) - Kane Casani has overall responsibility for the direction and evaluation of the New Millennium Program.

Project Center - Goddard Space Flight Center (GSFC) is responsible for overall project management. Code 470 is responsible for the Delta launch vehicle.

New Millennium Earth Observing Program Manager- Within GSFC, Dr. Bryant Cramer has responsibility for the direction and evaluation of New Millennium Program Earth Orbiting missions**.**

Project Manager for EO-1- Mr. Dale Schulz is the EO-1 Project Manager, and is responsible for ensuring the performance of all functions necessary for the management of all EO-1 project mission responsibilities.

Mission Systems Engineer - Mr. Peter Spidaliere is responsible for the overall mission Systems Engineering. He is supported by the NMP team.

1.1.4.2 Support Roles

EO-1 Mission Scientist - Dr. Steve Unger has responsibility for the overall scientific aspects of the EO-1 mission.

Ground Systems Project Manager - Mr. Daniel J. Mandl oversees the development and integration of the ground data system for the NMP EO-1 mission.

Mission Director - Mr. Daniel J. Mandl is responsible for the NASA operational support of the spacecraft after launch.

Mission Operations Planning and Support System Engineer- Mr. Randy Harbaugh is responsible for accepting the project's support requirements for the managing, planning, design, implementation, procurement and integration of the operational Mission Operations Center.

Mission Manager (Networks) - Mr. Paulino (Paul) Garza is the principal point of contact for mission support services and is responsible for defining the ground stations', telecommunications and Networks data processing and spacecraft to ground system requirements. Interfaces with the SOMO organization for the implementation of capabilities and integration and testing of required functions to meet mission requirements and ensures that all supporting elements are operationally ready.

SOMO Center Mission Services Manager - Mr. Richard N. Harris is responsible for coordinating all SOMO support requests of NASA resources in support of the EO-1 mission.

1.2 General Mission Information

1.2.1 Project Description

NMP's first Earth Observing flight will validate revolutionary technologies contributing to the reduction of costs and increased capabilities for future land imaging missions. These technologies include imaging instrumentation as well as spacecraft systems.

The imaging instruments are:

- Hyperion experiment
- Advanced Land Imager (ALI)
    - Multispectral Imaging Capability
    - Wide Field of View Reflective Optics
    - Silicon Carbide Optics
- Atmospheric Corrector (AC)

The spacecraft systems' technologies are:

- X-Band Phased Array Antenna (XPAA)
- Pulse Plasma Thruster (PPT)
- Light Weight Flexible Solar Array (LFSA)
- Carbon-Carbon Radiator (CCR)
- Enhanced Formation Flying (EFF) with the Landsat-7 spacecraft.

Launch is presently scheduled for December 1999, and the mission duration is one year.

1.2.1.1 Technologies Objectives

The onboard EO-1 technologies have the following objectives:

Technology	Objective
Hyperion	The Hyperion Instrument will support ALI and LAC validation and will demonstrate the capability of hyperspectral imaging spectroscopy for both science and application demonstrations.
Advanced Land Imager (ALI)	The ALI will demonstrate a low cost, lower mass multispectral imaging capability which could support future Landsat missions.
Linear Etalon Imaging Spectrometer Array/Atmospheric Corrector (LEISA/AC)	LEISA/AC will demonstrate a moderate resolution (250m GSD) hyperspectral imagery to support correction of land imagery due to atmospheric absorption.
X-Band Phased Array Antenna (XPAA)	XPAA will demonstrate a lightweight, high efficiency X-band Phased Array Antenna for downlinking stored EO-1 science instruments data.
Pulse Plasma Thruster (PPT)	PPT will demonstrate that the pitch wheel can be replaced with a thruster that uses Teflon propellant.
Light Weight Flexible Solar Array (LFSA)	The LFSA will demonstrate a lightweight solar blanket and shockless shaped hinge deployment mechanism to achieve 2 to 3 times the specific power over conventional solar arrays.
Carbon Carbon Radiator (CCR)	CCR is designed to have superior thermal radiating properties over conventional materials. The CCR is a passive structural element and is monitored through six thermistors as part of the Spacecraft State of Health information sent to the ground.
Enhanced Formation Flying (EFF)	EFF will demonstrate autonomous on-board relative navigation and formation flying control algorithms.

1.2.1.2 Mission Ops Concept

Mission operations for the EO-1 mission will be conducted from the MOC at GSFC and supported by NASA ground stations at Spitzbergen (SGS), in Svalbard, Norway, Poker Flat Alaska, (AGS), the Wallops Ground Station (WGS), Wallops Island, Va., and the McMurdo Ground Station (MGS), Antarctica station. The Space Network (SN) will be used for receipt of housekeeping telemetry during Launch and Early Orbit (L&EO) activities. During L&EO, the Mission Operations Center (MOC) will conduct on-orbit real time operations with increased staffing support to ensure necessary coverage for key launch and in-orbit checkout periods. Thereafter, the MOC will operate during day hours, five days a week. After the main mission, operations will be conducted using a more autonomous procedures mode.

EO-1 will fly in formation with Landsat 7 in order to obtain sets of common data for direct comparison with its equivalent Multi-Spectral (MS)/Pan Bands.

The EO-1 ground segment is shown in Figure 1 - 1, EO-1 Ground System.

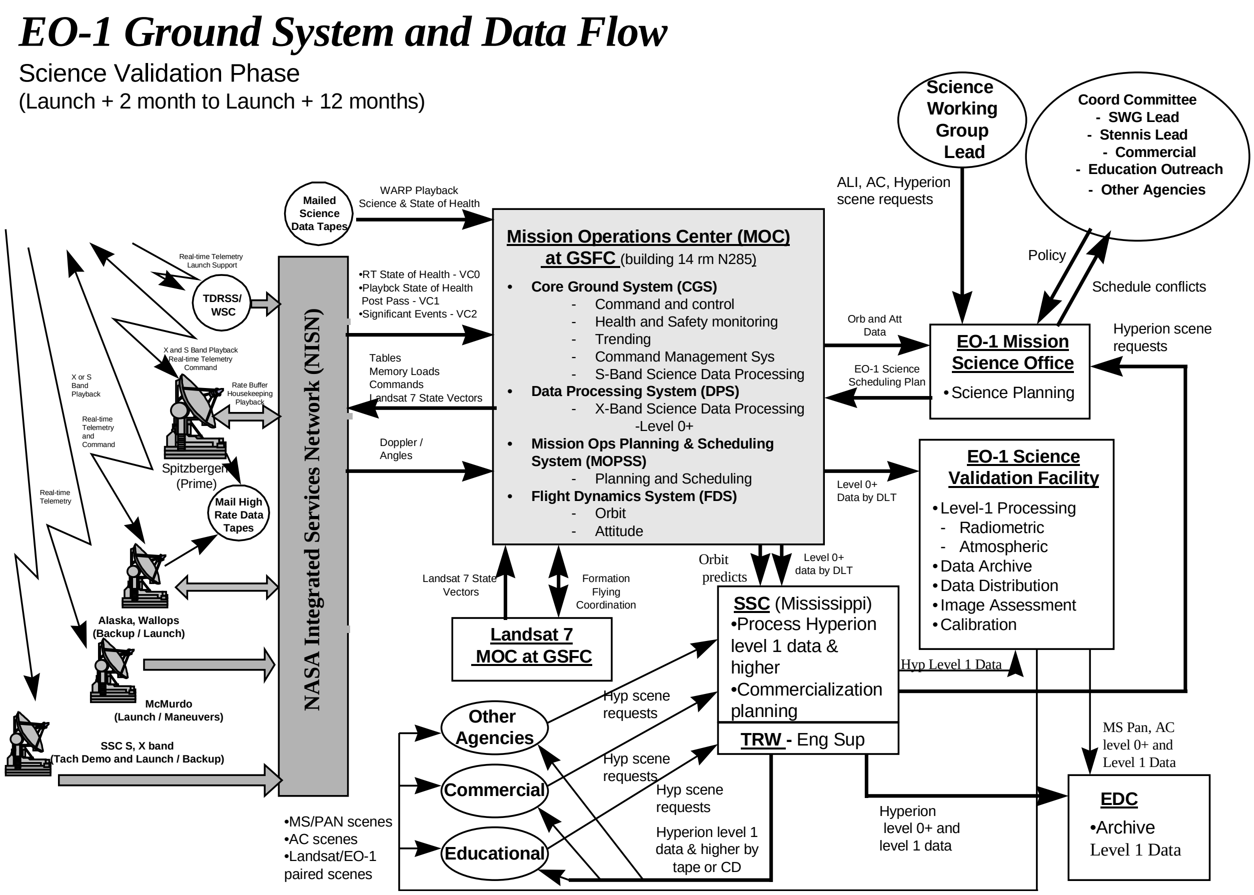

Figure 1 - 1. EO-1 Ground System Operations Overview

Functional Elements

Mission Operations Center (MOC)

The MOC is located within building 14 room N285 in GSFC and will control the EO-1 mission from launch through orbit insertion and on-orbit operations activities. The MOC is the source for spacecraft commands, and it also houses the spacecraft data processing (Level Zero Processing +), tracking processing, and analysis personnel and resources. Spacecraft orbit and attitude determination is performed at the MOC, using two-way Doppler and angle data provided by the remote ground stations. The MOC will create and provide Improved Interrange Vector (IIRV) messages to the ground stations and Network Control Center (NCC) for antenna pointing. The MOC will also provide scheduling predictions and products to the ground stations and NCC, and other mission support elements as required.

Ground Stations

Communications between the spacecraft and the supporting stations are provided as follows:

- Prime, S- and X-band:
  - Spitzbergen, Svalbard, Norway (SGS) station.
- Backup/L&EO, S- and X-band:
  - Wallops Ground Station at Wallops Island (WGS).
  - Alaska station at Poker Flat, Alaska (AGS)
- Backup L&EO and maneuver support, S-band:
  - McMurdo station in Antarctica (MGS).
- Backup L&EO, S-Band
  - Whites Sands Complex (WSC) in New Mexico (S-band return only, no commanding).

Wallops Orbital Tracking Information System (WOTIS)

The WOTIS provides a focal point for Ground Network (GN) direction and operational control of the ground stations activities and resources. Responsibilities of WOTIS include scheduling and control of changes to network services and configurations, conflict resolution, emergency scheduling, and scheduling of network testing support.

Standard Autonomous File Server (SAFS)

The SAFS systems are located at the ground stations and a central system at GSFC. They provide the MOC with an automated management capability of the mission science data files via direct access to retrieve the stored data in a timely fashion.

Network Control Center (NCC)

The NCC provides a focal point for Network direction and operational control of the Space Network (SN) activities and resources, including testing and simulations. As such, it provides the real time support interface between the SN and the users. Responsibilities of NCC include scheduling and control of changes to network services and configurations, conflict resolution, emergency scheduling, support of network testing, network performance and status monitoring, acquisition data generation and dissemination. The NCC is also responsible for the direction and control of SN fault isolation, NCC data base management, and development of operations procedures.

White Sands Complex (WSC)

WSC consists of three Ground Terminals (GTs) designated White Sands Ground Terminal (WSGT), Second TDRS Ground Terminal (STGT) and Guam Remote Ground Terminal (GRGT). The GTs operate and maintain the TDRS spacecraft constellation and their functional responsibilities fall within two categories: space segment operation and control, and ground segment operation and control.

The space segment consists of a constellation of satellites operating in geosynchronous orbits. A real-time, frequency translation repeater concept is used in operations of TDRSS telecommunication services for relaying signals between low-altitude earth orbiting spacecraft and the GTs.

The ground segment functions comprise the control, monitoring and maintenance of GT resources and processes, including the receipt, processing, and routing of both forward and return user services, anomaly investigation, control of systems' failovers, and contingency planning and control of the ground segment.

Science Validation Facility (SVF)

The SVF at GSFC is the principal science operations and analysis center and it is provided by the EO-1 Project. The SVF will be a 5-days-a-week (TBD), 8-hours-per-day (TBD) operation, primarily performing science planning, Landsat 7 compared scene taking planning, data analysis, level 1 data processing, Landsat 7 scene comparison and validation, and data distribution. The SVF will provide instrument commands and scene taking times to the MOC MOPSS.

Mission Science Office (MSO)

The MSO is responsible for implementing mission planning activities. It serves as the sole acquisition input of mission scene requests from the DOD, commercial users and the Validation Team. The MSO is staffed by the Coordinating Committee members who establishes scene acquisition guidelines and creates long term planning.

NASA Integrated System Network (NISN)/Nascom

NISN provides the voice and data communications circuits among all the supporting elements of the EO-1 mission from Integration and Test (I&T) through the launch and operations phases. This will be accomplished through the TCP/IP networks.

Nascom provides voice and data communications within GSFC facilities including TCP/IP connectivity.

Flight Dynamics Facility (FDF)

Flight Dynamics support for EO-1 is provided by a team comprised of GSFC and contractor personnel from the Information Systems Center (ISC) and the Guidance Navigation and Control Center (GNCC). This team is designing, developing, integrating and testing the Flight Dynamics Support System (FDSS) for the EO-1 MOC. Team members provide pre-launch support in matters of orbit, attitude, mission analysis, acquisition and scheduling data with this support extending for approximately 30 days after launch which is through the spacecraft checkout period. After that time, the operations of the FDSS will be conducted solely by members of the EO-1 Flight Operations team. Should contingencies arise, the ISC and the GNCC will provide assistance and/or consultation on an on call basis.

Launch Site

The EO-1 launch site is the Western Range at Vandenberg, California. Launch operations activities at the launch site require communications to support integration and End-to-End (ETE) testing, operations simulations, and launch. Voice and data communications are required between the launch site and GSFC. NISN provides data switching and monitoring capabilities via the TCP/IP networks.

1.2.1.3 Major Mission Phases

Support to the EO-1 mission will be categorized by the phases listed in Table 1-1 below.

1.2.2 Spacecraft/Payload Description

The EO-1 spacecraft will weigh approximately 588 Kg in the launch configuration, measuring approximately 1.9 meters in height and 1.5 meters in width. The total power at the Beginning-of-Life (BOL) is 750 watts. The spacecraft will be three-axis stabilized and nadir pointing in all mission phases. It will also maintain instrument and solar array Sun pointing.

Operational Phases	Orbit Type	Activities	Stations
Pre-launch Phase	N/A	Development of requirements, implementation of requirements via development and operation of system.	SGS, WGS, AGS, MGS, TDRSS
Launch Phase	Ascent	Final on-launch preparations; launch, launcher trajectory, injection, separation.	SGS, WGS, AGS, MGS, TDRSS
Early Orbit Phase (approx. 3 days)	Circular Polar Orbit	EO-1 activation, stabilization, deployment, initial acquisition, mission attitude established.	SGS, WGS, AGS, MGS, TDRSS
Spacecraft Checkout Phase (approx. 14 days)	Orbit Formation Trim	Checkout and calibration of spacecraft. Validation of spacecraft control. Perform initial orbit formation trim burns.	SGS, WGS, AGS, MGS
Instrument Checkout Phase (approx. 43 days)	Orbit Formation Trim	Checkout and calibration of instruments. Perform instrument functional and performance verification. Establish and maintain orbit formation.	SGS, WGS, AGS, MGS
Normal Operations Phase	Orbit Formation Maintenance	Maintain close separation with Landsat 7 (as close as one minute). Science validation of ALI, Hyperion and AC. Perform technology validation.	SGS, WGS, AGS, MGS
Extended Mission Phase	Circular Polar Orbit	TBD, after one year of operations.	TBD
Termination Phase	Circular Polar Orbit	Termination of mission operations.	TBD

Table 1-1. Operational Phases

1.2.2.1 Spacecraft/Payload Characteristics

The spacecraft consists of five main subsystems:

a. Structure. This subsystem will support and carry the EO-1 instruments and all other subsystem components.

b. Command and Data Handling (C&DH). This subsystem provides the communications link between the spacecraft and the ground, and within the spacecraft itself. Most C&DH functions are implemented within the Mongoose V processor. The MV processor provides the onboard capability to perform mission-unique functions as required, and provide autonomous operation of the spacecraft when it is not in contact with the ground.

c. Attitude Control System (ACS). The ACS provides 3-axis attitude control and determination for all phases of operations after separation from the launch vehicle. The ACS is comprised of the MV's ACS software, the Attitude Control Electronics (ACE) box, and a complement of sensors and actuators consisting of:

- Sensors
    - Gyros
    - Coarse Sun sensors
    - Star tracker
    - Global Positioning System (GPS) receivers
- Actuators
    - Reaction wheels
    - Magnetic torque rods
    - Thrusters

d. Power. The major components of the subsystem are the solar array, battery, and Power System Electronics (PSE). Power, generated by the solar panels, is supplied directly to the observatory loads. The busses are maintained at +28 volts during all mission phases. A Super Nickel-Cadmium (NiCd) battery stack supplies energy when spacecraft power requirements exceed array capability and during eclipse periods. The PSE controls battery charging and dissipation of excess energy through shunt regulators.

e. Thermal. This control subsystem will use passive thermal control elements, selected surface finish coatings, regulated conduction paths, and thermostatically-controlled heaters to regulate the internal spacecraft temperature.

1.2.2.2 Spacecraft/Payload Drawing

Figure 1-2 shows the deployed spacecraft.

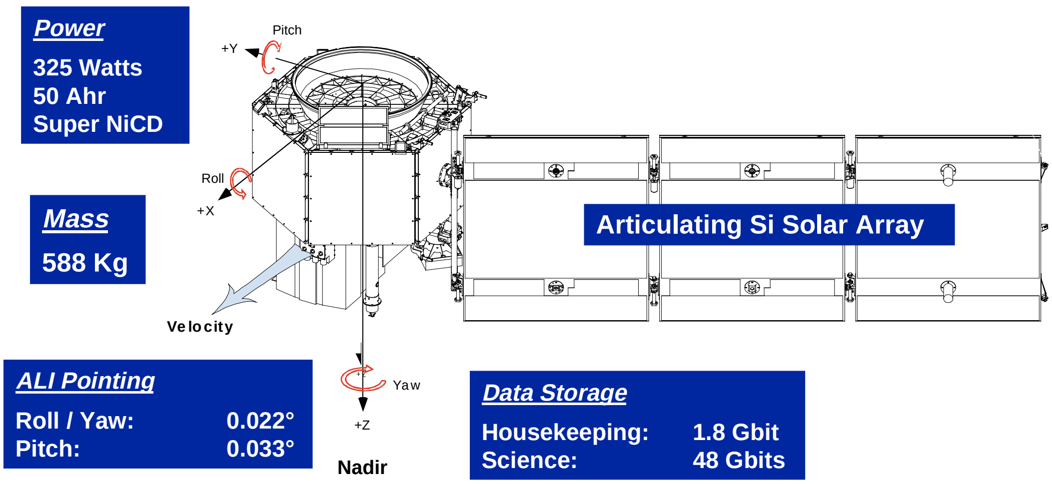

Figure 1 - 2. EO-1 Spacecraft

1.2.2.3 Spacecraft/Payload Telecommunications Subsystems

The telecommunications subsystem has both X- and S-band capabilities. The spacecraft has S-band semi omni-directional antennas and GPS patch antennae on both nadir and zenith-pointing surfaces. The S-band is intended for both command and control and housekeeping telemetry. One of the new technologies, a 64-element X-band phased array antenna is located on the nadir-pointing surface of the spacecraft. Imaging data will nominally be down-linked at a high data rate via the X-band system, but a backup capability is provided to down-link the data at a reduced rate via S-band. The data rates supported by the stations are listed in table 1 - 2 and the spacecraft RF communications subsystem is shown in figure 1 - 3 below.

The EO-1 spacecraft antenna complement is comprised of two transmit/receive S-band semi omni antennae and a transmit-only body-fixed X-band Phase Array Antenna (XPAA). One of the semi omni antennae is zenith facing and the other nadir facing. The semi omni antennae are right-hand circularly polarized (RHCP). Both antennae are connected by a diplexer to provide at least 80 percent hemispherical coverage for the spacecraft-to-GN links (70 percent for the backup payload mode). The 64-element X-band PAA is located in the nadir pointing surface of the spacecraft. The PAA is left-hand circularly polarized (LHCP) with a 3 dB beam width which varies from 18 to 30 degrees depending on scan angle. It scans a 360 degrees azimuth angle at up to a 65 degrees angle of elevation. Each of the 64 XPAA transmit elements contains its own solid state power amplifier.

Stations	Purpose	Band @ Rate
Spitzbergen (SGS) (Primary)	- Uplink command - Downlink stored and real-time telemetry - Downlink stored science data - Backup downlink stored payload data	- S-band @ 2 kbps - S-band @ 1 Mbps, 32 kbps, 2 kbps - X-band @ 105 Mbps - S-band @ 2 Mbps
Wallops (WGS) and Alaska (AGS) (Backup/L&EO)	- Uplink command - Downlink stored and real-time telemetry - Downlink stored science data - Backup downlink stored payload data	- S-band @ 2 kbps - S-band @ 1 Mbps, 32 kbps, 2 kbps - X-band @ 105 Mbps - S-band @ 2 Mbps
McMurdo (MGS) (Backup L&EO and Maneuver Support)	- Uplink command - Downlink stored and real-time telemetry	- S-band @ 2 kbps - S-band @ 32 kbps, 2 kbps
White Sands Complex (WSC) (Backup L&EO, Anomaly support)	- Downlink real-time H/K telemetry during launch.	- S-band @ 2 kbps

Table 1 - 2. EO-1 Data Types and Data Rates Summary

The XPAA amplifies and radiates the signal supplied via coaxial cable from a modulator/exciter which is contained within the Wideband Advanced Recorder Processor (WARP).

The X-band exciter/modulator within the WARP consists of a modulo 4-gray differential code QPSK modulator, an upconverter and a solid state power amplifier. An internal voltage control oscillator (VCO) is used to generate the 8225 MHz carrier frequency.

The EO-1 spacecraft S-band transponders will always be operating in receive mode during normal on orbit operation. The spacecraft will not transmit telemetry to the GN stations unless commanded by the EO-1 Mission Operations Center (MOC). The transmitter in the transponder is commandable On or Off. The S-band transponder down-converts and demodulates the received signals, recovers the baseband command data and clock signal. The recovered command data and clock signal, along with a lock indicator, are sent to the C&DH subsystem for command processing and execution. The spacecraft shall be accommodated by GN through the use of the spacecraft transponder STDN link mode.

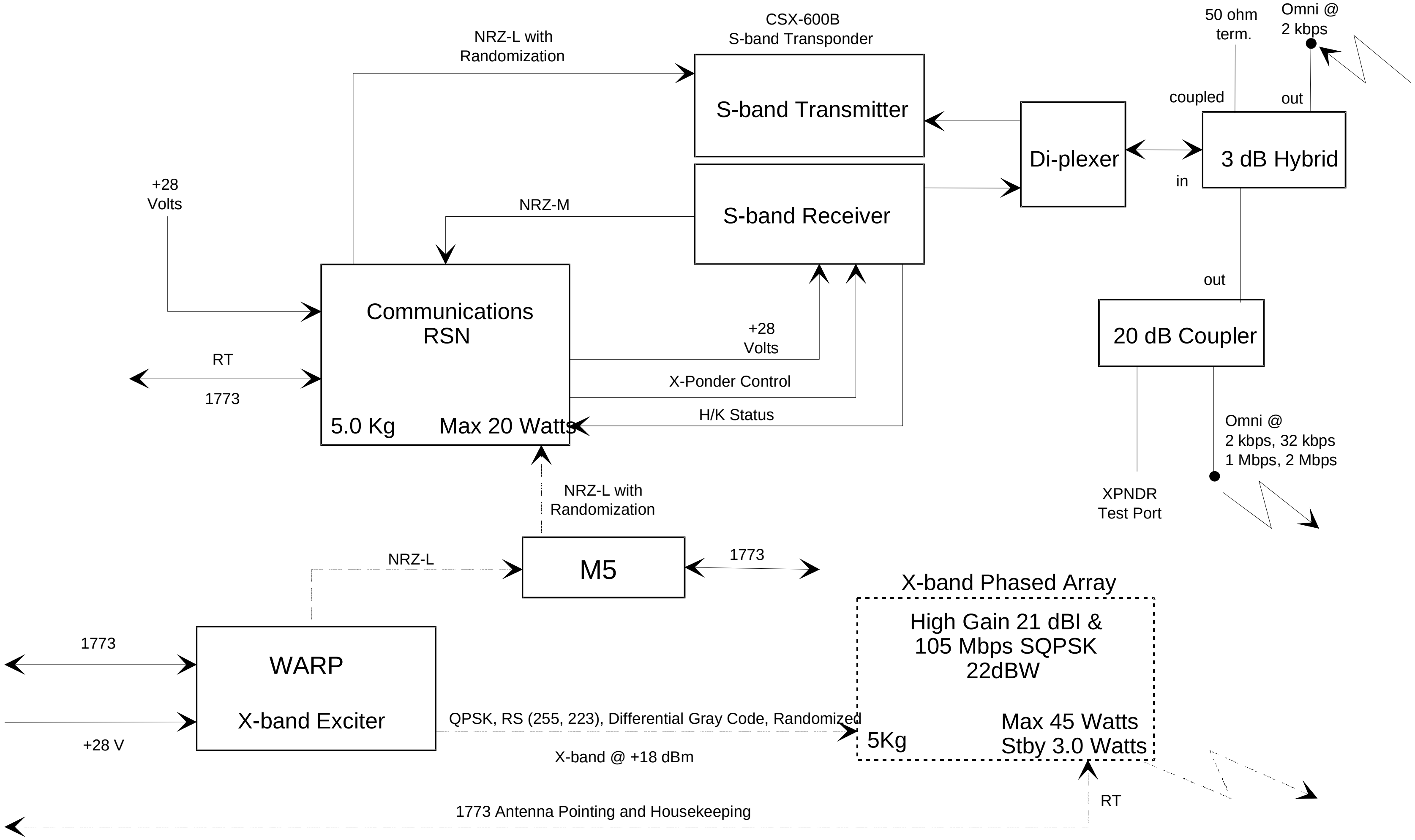

Figure 1-3. Spacecraft RF Subsystem Block Diagram

1.3 General Launch Information

The EO-1 spacecraft will be launched on a Delta 7320 launch vehicle co-manifested with the Argentine's Satelite de Aplicaciones Cientificas - C (SAC-C) from Vandenberg Air Force Base (VAFB), California. EO-1 is presently scheduled for a December 1999 launch, and the launch window is constrained by the requirement to be in the same plane as the Landsat 7 spacecraft. This limits the window to one or two minutes once every day.

Refer to the 501-601/Network Operations Support Plan for the Delta Launch vehicle for details of launch operations.

1.3.1.2.1 Major Mission Events

Major mission events for the launch phase are summarized in table 1 - 3 below.

Event	Time (Min:Sec)	Station Visibility (Nominal Launch)
Liftoff	0.00	***TBS***
Solid Motor Burnout (3)	1.04	
Solid Motor Separation (3)	1.50	
Main Engine Cutoff	4.21	
Vernier Engine Cutoff	4.27	
Stage 1-2 Separation	4.29	
Stage 2 Ignition	4.35	
Jettison 10 ft. Composite Fairing	5.00	
First Cutoff - Stage 2 (Second Engine Cutoff 1)	10.48	
Stage 2 Restart	50.00	
Second Cutoff - Stage 2 (Second Engine Cutoff 2)	50.14	
Separate EO-1 Spacecraft	55.00	
Separate Portion of Dual Payload Attachment Fitting	59.10	
Separate SAC-C Spacecraft	63.20	
AOS Spitzbergen, Norway *	76.24	
AOS Poker Flat, Alaska *	86.48	
LOS Spitzbergen, *	87.58	
LOS Poker Flat *	97.52	
Second stage Evasive Burn Ignition	100.00	
Third Cutoff - Stage 2 (Second Engine Cutoff 3)	100.05	
Second Stage Depletion Burn Ignition	108.20	
Stage 2 Depletion	109.00	***TBS***

Table 1 - 3. Major Launch Events

1.4 Orbit/Trajectory

The nominal operational orbit will be a circular polar orbit with a mean altitude of approximately 705 kilometers, with a inclination of 98.2 degrees, an orbital period of 98.9 minutes and a descending node that will be one minute behind that of Landsat-7's descending node at the time EO-1 is launched.

During the EO-1 mission operations phase, the spacecraft orbit will be controlled so that it maintains an orbit with high precision relative to Landsat 7 (one minute behind Landsat 7 on the same ground track). This will be performed via a ground command initially, switching to autonomously with ground support confirmation as a demonstration of new technology after approximately 90 days. Formation flying with Landsat 7 will enable the same scenes to be taken from both spacecraft at nearly the same time and under nearly the same environmental conditions. Refer to figure 1 - 4 below for the relative orbit between the spacecraft.

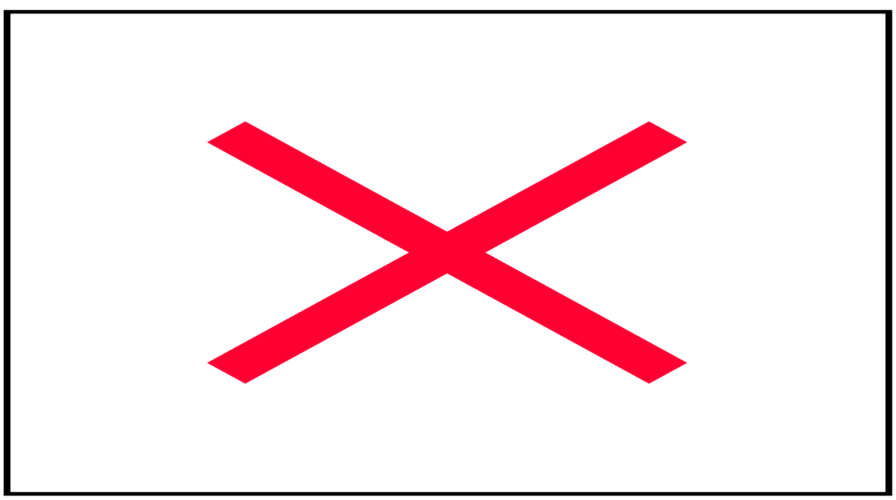

Figure 1 - 4. EO-1 Orbit Relative to Landsat 7 Spacecraft

1.5 References

1.5.1 Aerospace Data System Standards

Consultative Committee for Space Data Systems (CCSDS) Recommendations

1.5.1.1. CCSDS 401.0-B-2; Radio Frequency and Modulation Systems; Part 1: Earth Stations and Spacecraft

1.5.1.2. CCSDS 101.0-B-3; Telemetry Channel Coding

1.5.1.3. CCSDS 701.0-B-2; Advanced Orbiting Systems, Networks and Links: Architectural Specification

~~1.5.1.2.~~ 1.5.1.4. SMRD 3.1.7

1.5.2 Other Project/Technical Documentation

1.5.2.1. EO-1 Radio Frequency Interface Control Document, STDN 450-RFICD-EO1/STDN, July 1998.

1.5.2.2. EO-1 Mission Requirements Request

1.5.2.3. ~~1.5.2.3.~~ NASA Spacecraft to Ground Interface Control Document, Version 2, dated June 26, 1998 (or latest version).

1.5.2.4. EO-1 Ground Functional and Performance Requirements, dated March 30, 1999 at: eo1.gsfc.nasa.gov

Section 2. RF Telecommunications

2.0 Summary

The GN and SN Detailed Mission Requirements Document presents requirements that are levied on NASA's Network. The GN includes the S and X band antenna ground stations at Spitzbergen, Svalbard, Norway, (SGS), Poker Flat Alaska, (AGS), the Wallops Ground Station, Wallops Island, Va., (WGS) and the McMurdo, Antarctica station (MGS). The SN includes the Tracking and Data Relay Satellites, the White Sands Complex, and the Network Control Center (NCC). The EO-1 mission support will be required from the SN for support of EO-1 launch and early orbit operations, and emergency support during the mission. The EO-1 launch is planned for December 1999, and early orbit support will be limited to the first 60 days. Emergency support will be limited to times when the health and welfare of the mission are in jeopardy. The mission lifetime requirement is 1 year.

The EO-1 mission will require the following GN support:

- Every orbit - first 7~~3~~ days
- Six passes per day - first 60 days
- Three passes per day - through one year
- One to two additional supports per week for special operations, i.e. orbit maneuvers, and instrument lunar and solar calibrations - throughout the mission period

On S-band, the nominal telemetry downlink rate will be 1~~.024~~ Mbps, which includes stored housekeeping, event, new technology, and real-time data. The spacecraft also has a real-time housekeeping data only downlink mode, at 2 kbps or 32 kbps. SN will support 2 kbps data rate only. The 2.0 Mbps S-band downlink is a backup to the X-band science data, which is normally downlinked at 105 Mbps rate to the GN. The X-band signal is transmitted using LHCP.

The spacecraft communicates with the ground using two S-band RHCP semi omni antennae. The data is transmitted simultaneously through both antennae. At certain angles, there may be nulls in the antenna pattern, mainly for uplink mode, due to interference between the two antennae.

Further RF communications details are contained in the EO-1 GN/SN Radio Frequency (RF) Interface Control Document (ICD), dated July 1998.

2.1 RF Link Properties

2.1.1 Frequency Utilization Summary

EO-1 frequency utilization is shown in table 2 - 1 below.

2.1.2 Telemetry and Command Frame Structure

2.1.2.1 Telemetry Frame Structure

The EO-1 telemetry system is CCSDS compliant for both S-band and X-band data.

Link Frequency	Link Mode	Modulation	Data Rate/ Encoding Scheme	Data Type	Mod Index CMD	Mod Index TLM	Purpose and Remarks
S-Band Uplink 2039.65 MHz	Uplink	PCM/PSK/PM	2.0 kbps on 16 kHz sub-carrier	NRZ-M	0.5 rad		Real-time command, doppler tracking
S-Band Downlink 2215.5 MHz	Downlink	PCM/BPSK/PM	1.0 Mbps* Randomized, Reed-Solomon and CRC	NRZ-L		1.57 rad	Stored/real time housekeeping telemetry
*	Downlink	PCM/BPSK/PM	32 kbps *, or 2 kbps ~~*~~* Randomized, Reed-Solomon and CRC	NRZ-L		1.57 rad	Real-time housekeeping telemetry
	Downlink	PCM/BPSK/PM	2.0 Mbps* Randomized, Reed-Solomon and CRC	NRZ-L		1.57 rad	Stored payload/science data (backup to X-band)
X-Band Downlink 8225. 0 MHz	Downlink	PCM/QPSK/PM	I Ch: 52.5 Mbps Q Ch: 52.5 Mbps (I:Q Power Ratio 1:1)	NRZ-L		1.57 rad	Science Data

~~Note: ** Convolutional encoded 1/2 rate used for TDRSS 2 kbps SSAR only~~Note: *~~:~~S-Band data rates are rate ½ convolutionaly encoded.

Table 2 - 1. Frequency Utilization Summary

Refer to figure 2-1 for the S-band and X-band telemetry data format.

Total CADU Length = 1264 bytes

4 bytes | 1100 bytes | 160 bytes

	VCDU Primary Header						VCDU Insert Zone			M_PDU Header		M_PDU Packet Data Zone	VCDU Trailer	RS Check Symbols
SYNC Mark	Ver No.	S/C ID	Virt Ch	VCDU Cntr	Replay Flag	Spare	Recdr ID	Spare	Recorded VCDU Cntr	Spare	1st Hdr Pointer	Packet Data	Err Ctrl CRC	
32	2	8	6	24	1	7	8	8	32	5	11	8,672	16	1280

10 bytes Inserted by the processor at playback

1092 bytes Recorded H/K Data from the Bulk Memory

162 bytes Inserted by H/W at Playback

a2823006.dsf:x:n

Figure 2 - 1. S-Band and X-Band Telemetry Data Format

2.1.2.2 Command Frame Structure

The EO-1 command system is also CCSDS compliant. Refer to figure 2 - 2 for the command data format. Further telemetry and command data interface details are contained in the EO-1 Spacecraft to Ground Interface Control Document (ICD), version 2, dated June 26, 1998.

2.2 Networks

2.2.1 SN Requirements

The SN SSA service is required to support the launch and early orbit phase of the EO-1 mission to maximize the amount of time for real-time housekeeping telemetry contacts. SN will support 2 kbps telemetry data only. There are no requirements for tracking or forward services. The SN requirements are listed in tables 2-2 and 2-3, and the SN support configuration is shown in figure 2-4.

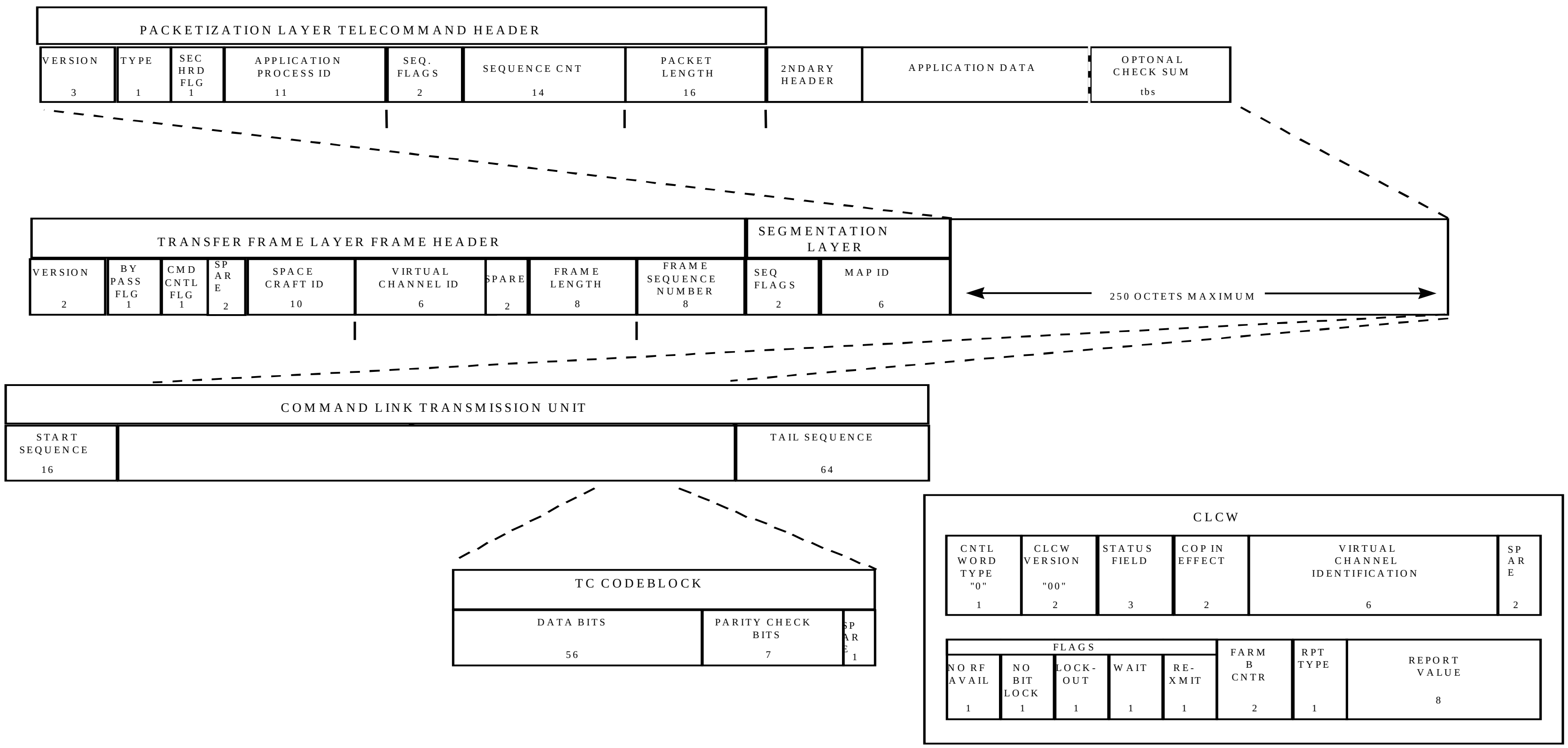

Figure 2-1. S-Band Command~~and X-band Telemetry~~ Data Format

Requirement No.	Requirement Description	Response
	Scheduling/Acquisition Data	
221.1	The SN NCC shall accept requests via voice, e-mail or facsimile from the EO-1 MOC for scheduling the SN service, generating Ground Control Messages Requests (GCMRs) to reacquire SSA services as required (but not to change data rates), and providing status on the SN operations in support of EO-1	
221.2	The SN NCC shall accept an IIRV of the EO-1 orbit from the EO1 MOC. The vector shall be provided by FTP.~~, the same as for Landsat-7.~~	
	Tracking	
	There are no SN requirements to provide tracking data services.	
	Telemetry	
221.3	The SN shall provide SSA return services (DG2 noncoherent mode) to EO-1 during the launch and early orbit checkout of the EO-1 spacecraft.	
221.4	~~The EO-1 post launch initial checkout will require approximately 3 days.~~ EO-1 will use the SSA return link during separation and for approximately 3 orbits ~~thereafter~~.	
221.5	After the initial checkout, the following TDRS support may be requested for EO-1: a. Initial lunar scan - (1 orbit duration) at approx. launch + 3 weeks. b. Initial solar calibration - (1 orbit duration) at approx. launch + 4 weeks. c. Ascent maneuver – (first 2 to 3 weeks) d~~c~~. Inclination burn - (1 orbit duration) at approx. launch + 6 months. e~~d~~. Emergency - (duration as required) - if significant contingency occurs.	
221.6	The EO-1 contacts will be as long as required for mission critical events.	

Table 2 - 2. SN Requirements Summary

221.7	The SN shall provide SSA return service to EO-1 to support spacecraft anomaly investigations.	
221.8	The data rate for the SSA service will be 2 kbps.	
221.9~~10~~	The throughput delay (time of reception from the satellite to transmission to the MOC) at the SN for R/T telemetry shall be less than 4 seconds.	~~(TBD)~~
221.10~~1~~	SN shall transmit all data to the MOC via TCP/IP protocol using the SMEX header as specified in ~~paragraph 1.5.2.3 of this document.~~ The EO-1 Space to Ground ICD.	
221.12	The SN shall provide a BER of 10E-5 at the output of WSC bit synchronizer interface.	
	Command	
	There are no SN requirements to provide command data services.	

Table 2 - 2. SN Requirements Summary (Cont.)

Mission Phase	**Service Name**	**Data Group**	**Data Type/ (BPSK Modulation)**	**Data Rate**	**Mod Index (rad)**	**Contacts Day**	**Duration**
L&EO	SSA	DG2	Single channel	2 kbps	1.57	As req.	As req..
Anomaly	SSA	DG2	Single channel	2 kbps	1.57	As req.	As req.

Table 2 - 3. SN - SSA Return Link Requirements Overview

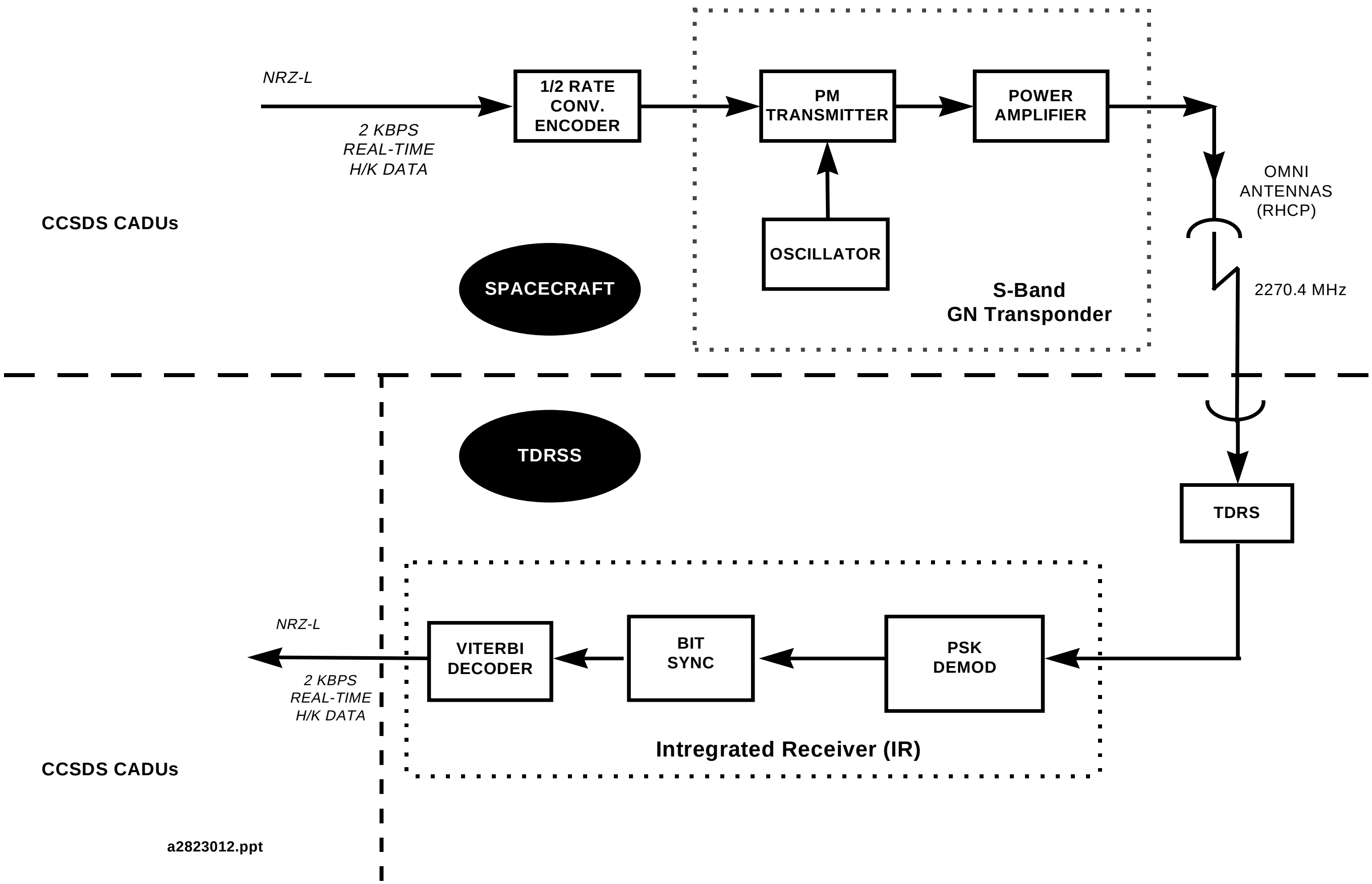

Figure 2 – 4. Spacecraft/SN S-band Downlink Configuration

2.2.2 DSN Requirements

N/A

2.2.3 GN Requirements

Upon request from the E0-1 MOC, the Wallops Flight Facility (WFF) is required to arrange spacecraft support from the ground stations at Spitzbergen (SGS), Norway, the Wallops Ground Station (WGS) at Wallops Island, at Poker Flat (AGS), Alaska, and at McMurdo (MGS), Antarctica. The GN requirements are listed in tables 2-4 and 2-5, and the GN support configuration is shown in figures 2-5, 2-6, 2-7 for S-band downlink, X-band downlink, and S-band uplink respectively.

Requirement No.	**Requirement Description**	**Response**
	Scheduling/Acquisition Data	
223.1	Wallops GN scheduling shall automatically generate schedules for the ground stations based on requests from the EO-1 MOC and according to mission generic scheduling rules.	
223.2	The GN shall accept an IIRV of the EO-1 orbit from the MOC. The vector shall be provided by FTP to Wallops~~, the same as for Landsat 7.~~	
223.3	During L&EO, GN shall receive and process acquisition data updates within 5 minutes of receipt from GSFC.	
	Tracking	
223.4	The GN shall provide the MOC FDSS angle tracking and doppler data as scheduled.	
223.5	~~***(TBR)*** Coherent Ranging. One to two passes per week with 2-way coherent ranging are needed from WGS for use in a backup mode spacecraft clock correction computation.~~	deleted
223.6	Doppler Tracking. The GN shall generate 2-way Doppler tracking data that is derived from the spacecraft 240/221 ratio coherent turnaround RF carrier to GN stations.	
223.7	~~The GN shall also generate 1-way Doppler tracking that is derived from the spacecraft to GN RF carrier.~~	Requirement deleted

Table 2 - 4. GN Requirements Summary

	Tracking (cont.)	
223.8	The 3-sigma tracking accuracy required from WFF is as follows: Noise / Bias Range: 3.0 meters / 15.0 meters Doppler: 1.0 mm/sec / 0.0 Angles: 0.01 degrees / 0.08 degrees	
	Telemetry	
223.9	The GN shall provide S- and X-band telemetry data services during the EO-1 mission life cycle.	
223.10	The GN shall time tag EO-1 telemetry data with an accuracy of at least 10 milliseconds. (Goal is 1 millisecond)	~~(TBD).~~
223.11	The throughput delay (time of reception from the satellite to transmission to the MOC) at the GN for real time telemetry shall be less than 4 seconds.	~~(TBD).~~
223.12	The data rates for each station and link are specified in table 2-5 below.	
223.13	GN shall receive S-band telemetry downlink, process and transfer in real-time housekeeping VC0 and VC2 data to the MOC via TCP/IP protocol.	
223.13a	GN shall perform telemetry data derandomization prior to distribution to the MOC. The MOC will perform Reed Solomon data decoding. Stations shall use downlinked CRC value to evaluate telemetry data quality.	
223.13b	GN shall provide data quality annotation to each S-band telemetry frame which is determine based on frame lock status and check of downlinked CRC.	
223.14	GN shall receive S-band telemetry downlink, and transfer all S-band data to the SAFS within 1 hour. The MOC will retrieve data from SAFS as required.	
223.15	In the event of a problem with the real time transmission, the GN shall provide the capability to transfer stored telemetry via File Transfer Protocol (FTP) to the MOC post-pass.	

Table 2 - 4. GN Requirements Summary (Cont.)

223.16	GN shall receive S-band 2 Mbps science data (backup for X-band), transfer data to the MOC via FTP post pass.~~pass and/or record in magnetic media, and mail once a week to the MOC.~~	~~(TBD)~~ ~~(TBD)~~
223.17	GN shall receive X-band 105 Mbps science data, record to Ampex recording system, model ***DIS260***~~***(TBS)***~~ , and mail twice a week to the MOC during normal operations, or mail within 24 hours during L&EO and~~a~~ spacecraft anomalies~~y~~. Tapes will contain EO-1 data only and be labeled with time and pass # info.	~~(TBD)~~ ~~(TBD)~~
223.18	The GN shall be capable of storing and maintaining all raw telemetry data for up to 7 days for S-band data and 30 days for X-band data or as directed by the MOC.	~~(TBD)~~
223.19	The GN shall replay S-Band or ~~re~~send the backup X-Band tape~~data~~ on request.	
223.20	The GN shall monitor data quality during the X-band downlinks. The baseband quality parameters shall be collected on a per channel basis and consist of # of frame syncs detected, # R/S errors and virtual channel counts.~~the same as collected for EOA AM project through their EDOS LZP interface(includes frame sync, R/S and Virtual channel counts)~~	
223.21	The GN shall forward the data quality information as a report sent electronically within 2 hours after each pass.	
223.22	The GN shall provide a BER of 10E-5 at the output of the station bit synchronizer interface.	
223.23	During L&EO and Contingency Ops, the Wallops station shall acquire selected X-band data which shall be sent on next available express delivery to MOC.	
	Command	
223.24	The GN shall provide S-band command data services during the EO-1 mission life cycle.	
223.25	The command data rate will be 2 kbps NRZ-M formatted data which phase-shift-key modulates a 16 kHz sinusoidal subcarrier. The command data bit clock shall be coherent with the 16 kHz subcarrier.	
223.26	The GN shall generate an alternating one/zero idle	

	pattern at the PSK modulator when carrier is locked and no commands are being transmitted. The commands will override the idle pattern when uplinking commands to the spacecraft.	
223.27	The GN 11-meter antenna stations shall provide a minimum EIRP of at least 97-dBm (94-dBm for 10-meter McMurdo station) signal at the uplink antenna output.	
223.28	The GN shall not introduce errors into the EO-1 command data at a BER greater than 10E-6 referenced to the spacecraft differential decoder output.	

Table 2 - 4. GN Requirements Summary (Cont.)

	Station Status Monitoring	
223.29	The GN shall provide station status data to the MOC every ten seconds. This shall include status on the following information: • station configuration • signal levels – (AGC) • antenna AZ-EL • carrier and telemetry lock status (S- and X-band) • telemetry and command statistics to include per VC S-band telemetry quality	
223.30	Provide post-pass pass summary report regarding contact related operations, i.e. command, telemetry, tracking, and record activities, etc. within two hours after the pass.	

Table 2 - 4. GN Requirements Summary (Cont.)

Stations	Purpose	Band @ Rate
Spitzbergen (SGS) (Primary)	- Uplink command - Downlink stored and real-time telemetry - Downlink stored science data - Backup downlink stored payload data	- S-band @ 2 kbps - S-band @ 1 Mbps, 32 kbps, 2 kbps - X-band @ 105 Mbps - S-band @ 2 Mbps
Wallops (WGS) and Alaska (AGS) (Backup/L&EO)	- Uplink command - Downlink stored and real-time telemetry - Downlink stored science data - Backup downlink stored payload data	- S-band @ 2 kbps - S-band @ 1 Mbps, 32 kbps, 2 kbps - X-band @ 105 Mbps - S-band @ 2 Mbps
McMurdo (MGS) (Backup L&EO and Maneuver Support)	- Uplink command - Downlink stored and real-time telemetry	- S-band @ 2 kbps - S-band @ 32 kbps, 2 kbps

Table 2 - 5. GN Stations and Link/Data Rates Summary

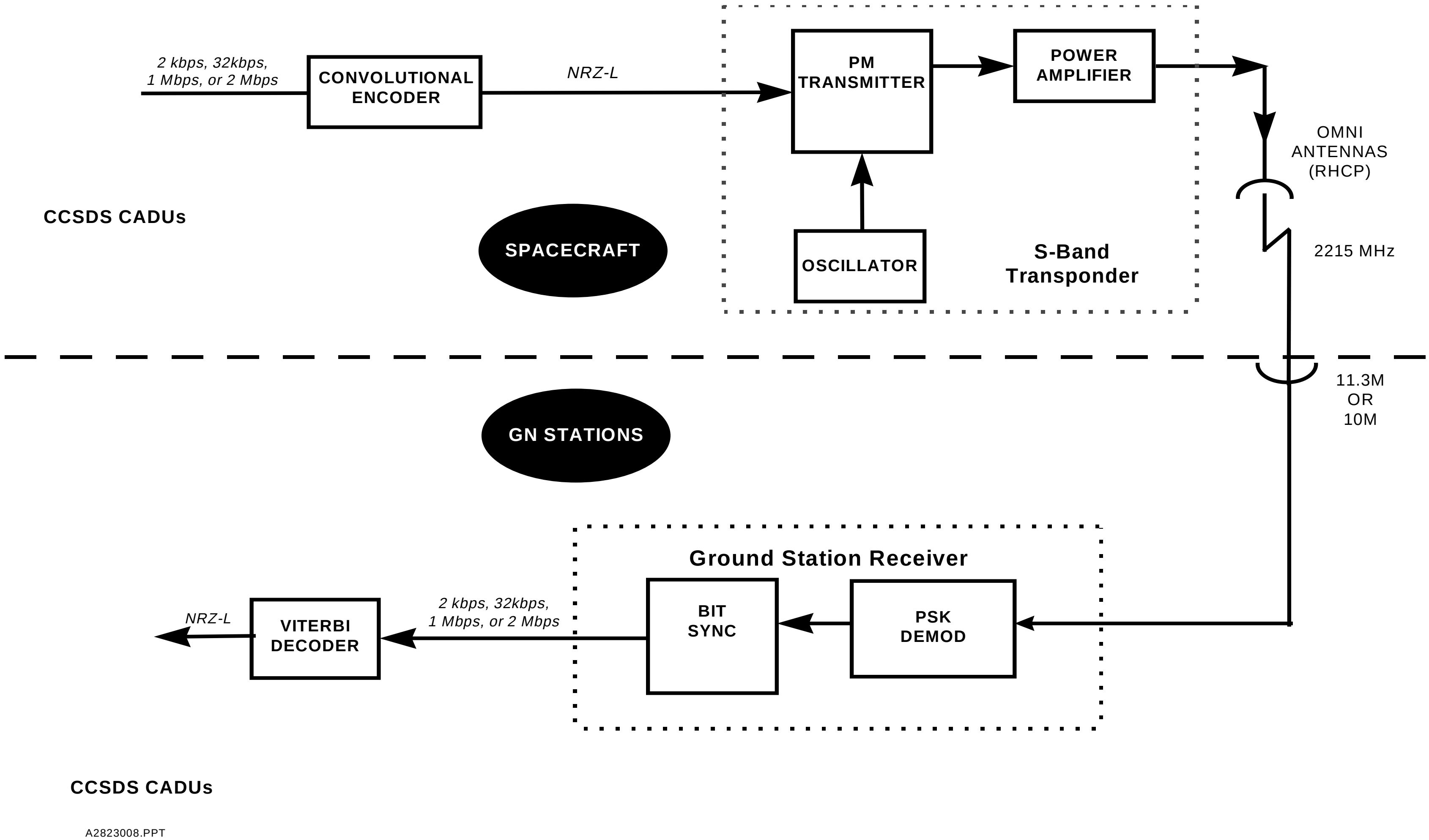

Figure 2 – 5. Spacecraft/GN S-band Downlink Configuration

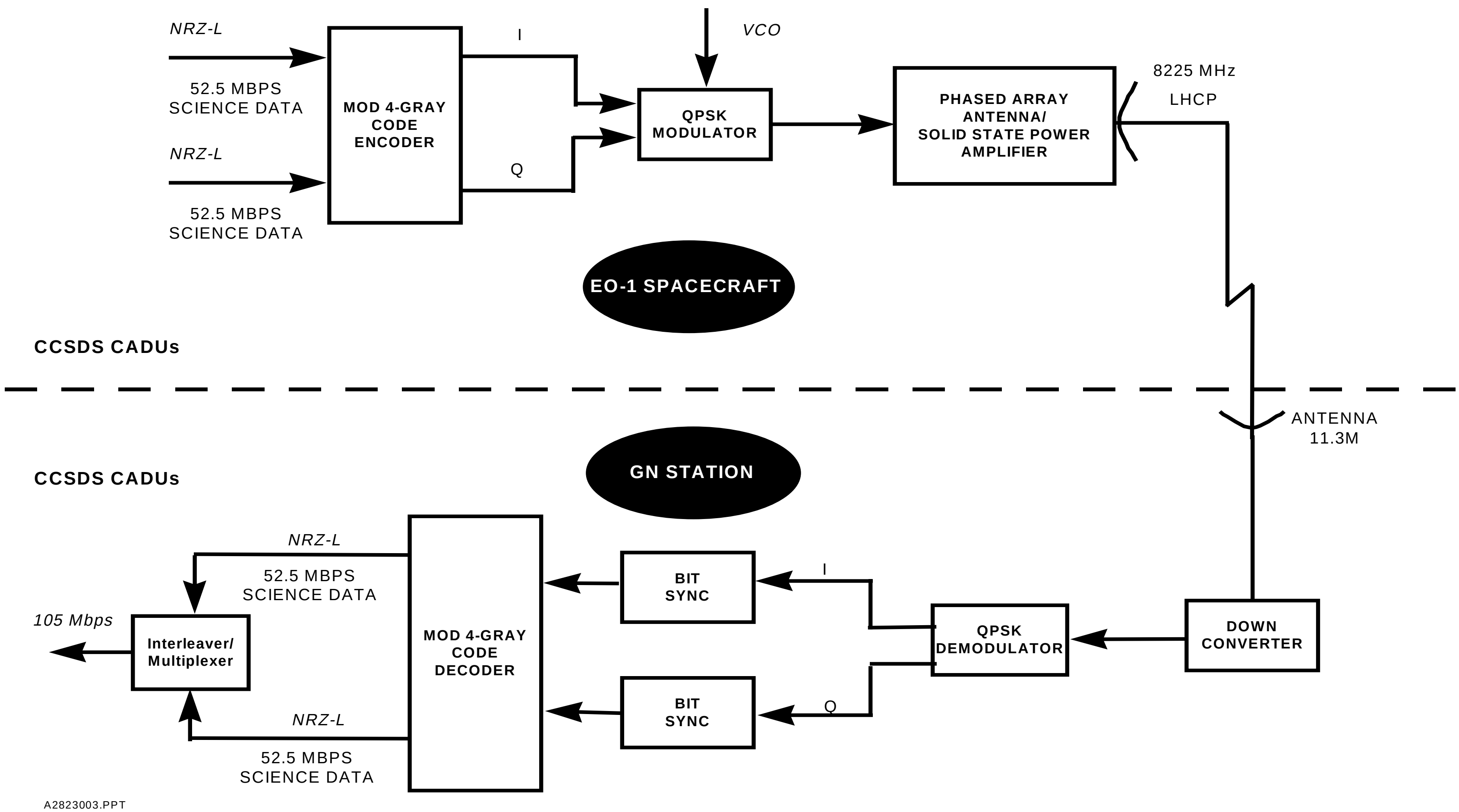

Figure 2 – 6. Spacecraft/GN X-band Downlink Configuration

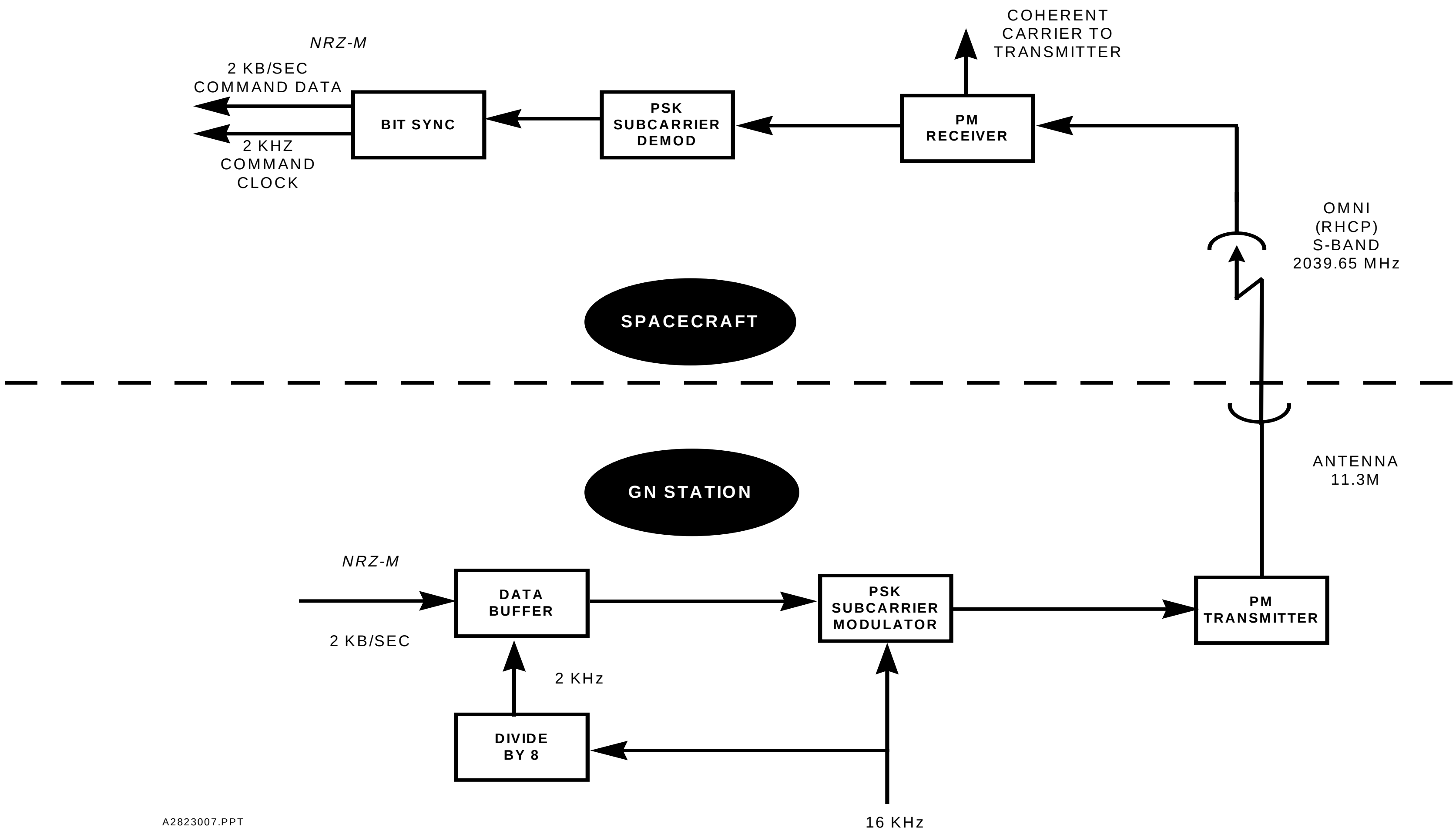

Figure 2 – 7. GN/Spacecraft S-band Uplink Configuration

2.2.4 Interagency Requirements

The DOD radar tracking network shall provide skin tracking data to the EO-1 mission from spacecraft separation to approximately four and a half hours. TBD

Requirement No.	Requirement Description	Response
	Tracking	
224.1	Skin tracking. The DOD radars listed below shall provide to the EO-1 MOC 46-character tracking data from spacecraft separation for approximately four and a half hours. ~~TBD~~	
224.2	The following radar stations shall provide the number or passes: Trackers — No. of passes Vandenberg (VD4F) — 1 Kaena Point (KPTQ) — 2	

Section 3. Testing and Training

3.0 Summary

Testing is required between the EO-1 spacecraft and the NASA support systems to verify that the capability to provide operational support has been implemented as required. Detailed information on the tests required to verify the stated capability will be developed over time, along with a schedule for coordinating project and support organization resources for conducting those tests. This information will be documented in the Integrated Test Plan which will be available in the EO-1 Home Page at http://E01.gsfc.nasa.gov. In general, compatibility and integrated testing will be conducted during a period between 12 months and until just prior to launch to ensure proper systems' support preparation. These tests will involve spacecraft and ground subsystems or simulators early on, and actual flight and support hardware as the launch date approaches.

3.1 Integrated Testing

3.1.1 EO-1 project will have an integrated testing approach for mission preparation including spacecraft compatibility, GN, SN, and all ground systems readiness to support the EO-1 mission.

3.1.2 The integrated testing will include the following categories of tests:

3.1.2.1 Software Validation (Category S).

S1: Core Ground System (CGS) Acceptance Test

S2: Mission Operations Planning and Support System (MOPSS) Acceptance Test

S3: Wallops Ground Station (WGS) Acceptance Test

S4: Flight Dynamics Support System (FDSS) Acceptance Test

S5: Data Processing System (DPS) Acceptance Test

S6: Year 2000 (Y2K) Test

3.1.2.2 Mission Readiness Test (Category T)

T1: Spacecraft to MOC Interface Test

T2: Spacecraft – MOC –MOPSS – CMS – FDSS Interface Test

T3: Spacecraft – MOC - MOPSS – DPS - SVF Interface Testing

T4: RF Compatibility Test

T5: MOC to Ground Stations Interface Test

T5.1 MOC to TDRSS Interface Test

T6: MOC – WTR – Interface Test

T7: Fully Integrated End-to-End System Test

3.1.2.3 Simulations (Category M)

M1: Launch Simulations

M2: Normal Operations Simulations

M3: Contingency Simulations

M4: Launch Rehearsal

3.1.3 Each test or simulation shall have test/sim sheets to include the following:

- Overview
- Requirements to be tested
- Participating elements
- Prerequisites
- Test data source
- Test Scenario
- Test Procedures

3.1.4 Each test and simulation activity will identify specific requirements to be tested. However, the EO-1 mission general functional test requirements are listed in table 3 - 1 below.

Requirement No.	**Requirement Description**	**Response**
314.1	The Compatibility Test Van (CTV) shall test for RF, command, telemetry and transponder interface compatibility for S-band, both GN and SN (no command), and X-band, GN only.	

Table 3 - 1. General Functional Test Requirements Summary

314.2	The CTV shall provide the MOC with a direct RF link to TDRS for system end-to-end testing with the EO-1 spacecraft.	
314.3	The CTV shall provide project a magnetic tape with spacecraft data recorded during compatibility testing. This tape shall be copied and used during subsequent I&T testing and simulations.	
314.4	MOC and WOTIS systems shall demonstrate the capability of scheduling GN and support resources as required.	
314.5	MOC and NCC shall verify the capability of scheduling SN resources via voice request, or e-mail ,or facsimile.	
314.6	MOC, GN and SN systems shall demonstrate the capability to exchange IIRV and tracking data (GN only) using the required formats.	
314.7	GN and SN shall provide the capability of generating test data from magnetic tape sources for data flows, I&T and simulations activities.	
314.8	MOC and supporting elements shall verify the capability to receive and process test data and generate products as required.	
314.9	All elements shall verify correct man-machine interface capabilities throughout testing and simulations process.	
314.10	Simulations shall validate operational procedures for normal and contingency modes for the required mission phases.	
314.11	All elements shall demonstrate capabilities of failure identification and corrective action procedures.	

Table 3 - 1. General Functional Test Requirements Summary (cont.)~~)~~

3.2 Integrated Simulations and Test Tools

The EO-1 project virtual simulator and actual spacecraft recorded data in magnetic tapes will be used as the test data source throughout the entire mission preparation. The spacecraft data for testing will be available by March 1, 1999~~***(date TBS by Project)***~~.

3.3 Training

Each EO-1 mission element shall define and control their corresponding systems operations certification program. Project training requirements, above and beyond the standard certification program, are not defined as of the time this document was written.

Section 4. Mission Operations

4.0 Summary

The MOC will operate and control the EO-1 mission from pre-launch through the life cycle of the spacecraft. The MOC will utilize SN and GN resources, as well as other supporting elements as required, to achieve the mission objectives.

The mission operations procedures are documented in EO-1 Mission Procedures Document. The requirements for the MOC are documented in the EO-1 Ground Functional and Performance Requirements with further details in the EO-1 Space to Ground ICD. All three~~Both~~ documents are located on the EO-1 project website:

http://eo1.gsfc.nasa.gov

Section 5. Ground Communications and Data Transport

5.0 Summary

NASA Integrated System Network (NISN) is required to provide voice and data circuit interfaces to support EO-1 operations from pre-launch testing through launch and operational phases. This function includes voice and data interfaces between MOC facilities at GSFC and VAFB launch site, SN and GN facilities, and Swales facilities, and other GSFC facilities as required. All elements shall have the capability to communicate via network communications services using Transmission Control Protocol/Internet Protocol (TCP/IP) . The overall mission configuration is shown in figure 5-1 for normal operations and in figure 5-2 for pre-launch and L&EO operations.

NISN shall provide the following full duplex TCP/IP circuit connectivity with associated bandwidths between listed locations and MOC at GSFC as shown in table 5-1 below.

Note: To allow connection to the closed NISN network, a NISN order must be submitted two months prior to the required date.

~~Table 5 - 1. NISN Data Bandwidth Requirements~~

~~Figure 5 – 1. EO-1 Data Link Operational Configuration~~

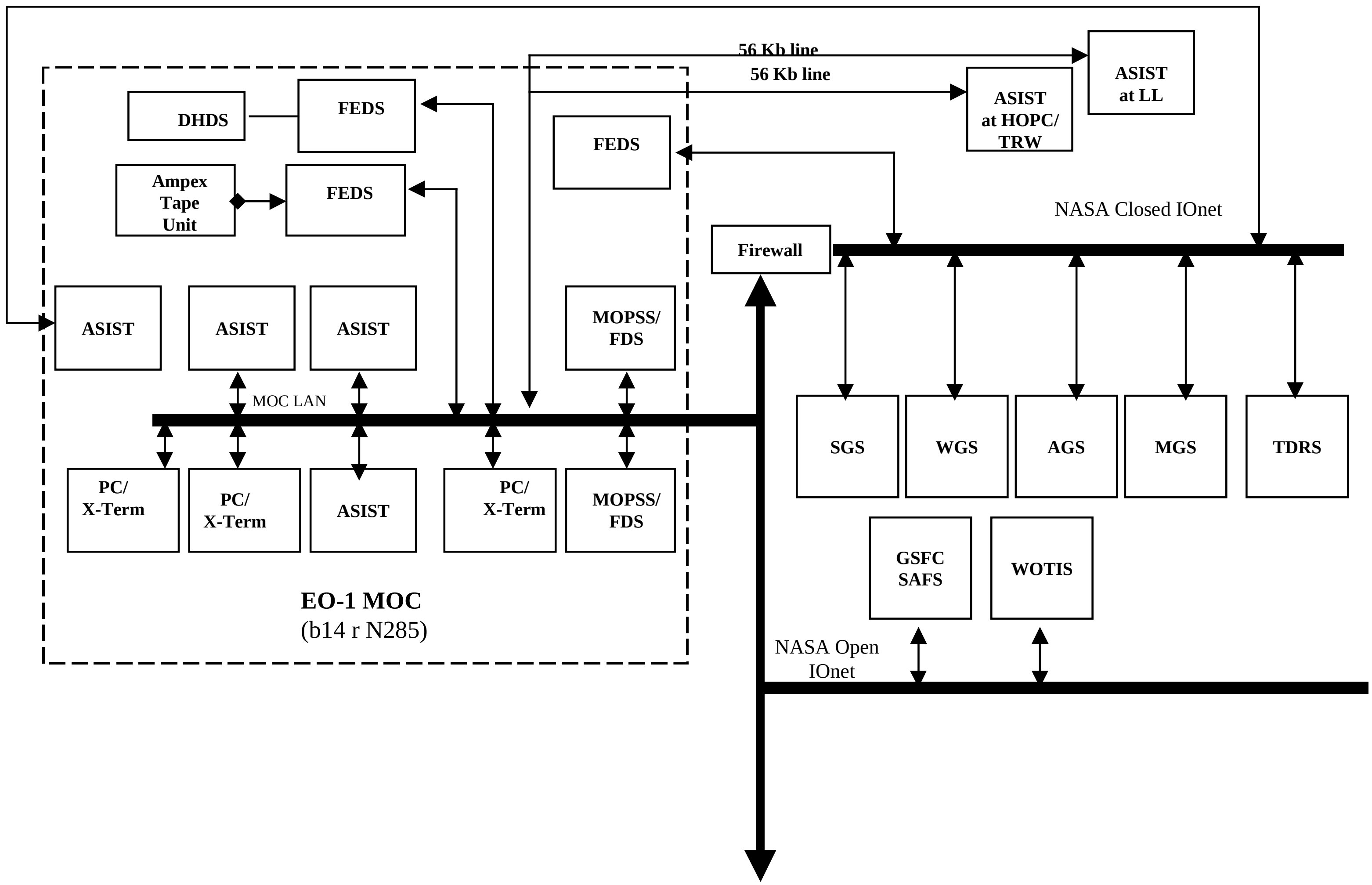

Figure 5-1. EO-1 Data Link Operational Configuration

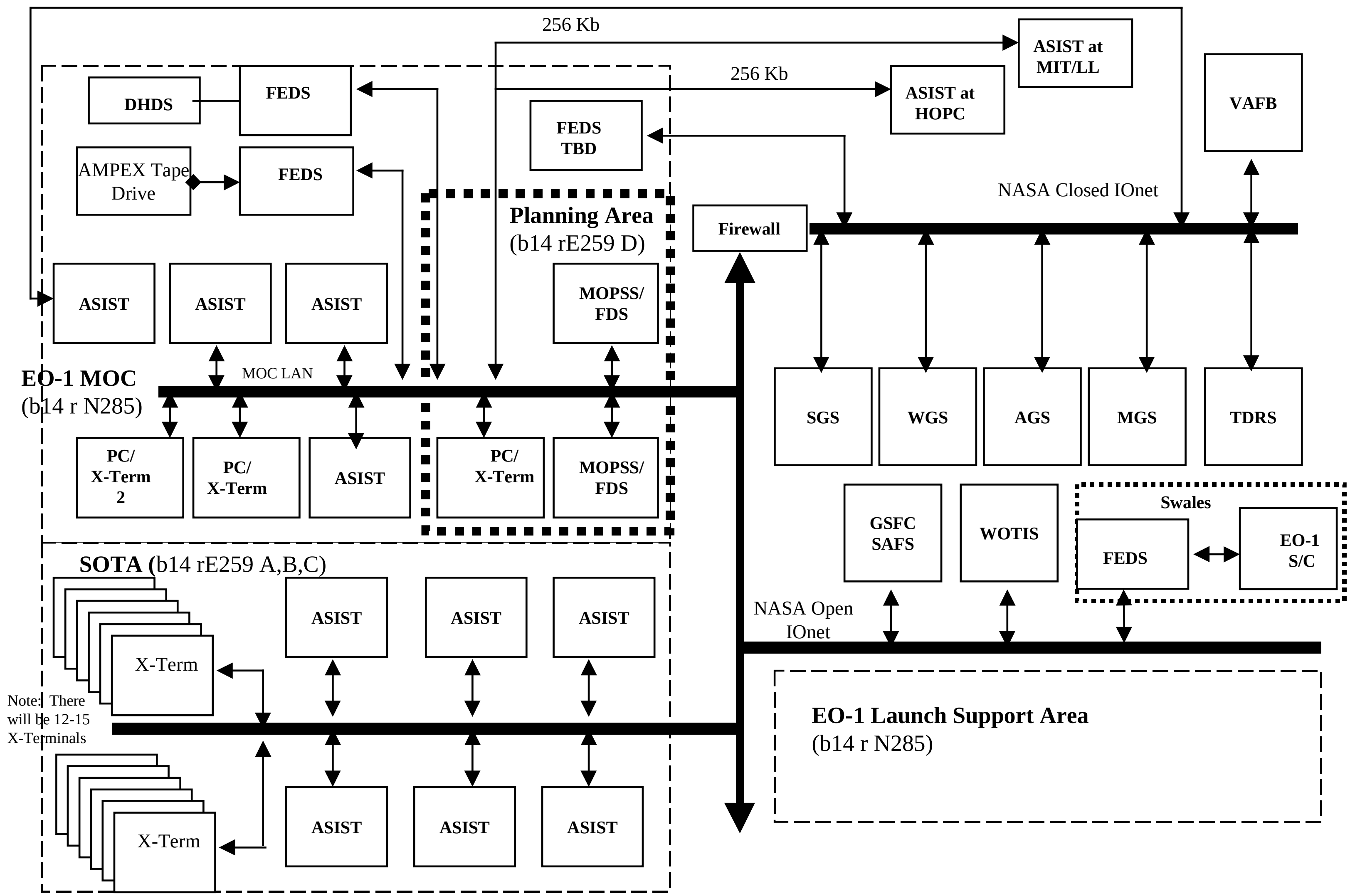

Figure 5.2.. EO-1 Data Link for Testing and Early OrbitConfiguration

~~Figure 5 – 2. EO-1 Data Link Testing and Early Orbit Configuration~~

5.1 Table of Connectivity

The telemetry and command data line assignments are detailed in table 5 - 2, Data Link Requirements. Similarly, voice line assignments for the various mission phases are contained in table 5 - 3, Voice Link Requirements.

Item #	From	To	1-Way or 2-Way	Data Source	Source Data Rate or Volume	Delivery Time	Service Dates(s) and Duration	Purpose and Remarks
1	EO-1 MOC	SWALES	2	Command and Telemetry	32k	Continuous	Present to May 99	Open Ionet, TCP/IP
2	EO-1 MOC	GSFC bldg 7	2	Command and Telemetry	1 Mb	Continuous	May 99 to September 99	Open Ionet,TCP/IP
3	EO-1 MOC	VAFB	2	Command and Telemetry	T-1		September 99 to Jan 00	Closed Ionet,TCP/IP
4	EO-1 MOC	WSC	1~~2~~	Telemetry	2k		May 99 end of mission	Closed Ionet.TCP/IP
5	EO-1 MOC	WPS, AGS, SGS	2	Command and Telemetry	32k	Real-time	May 99 end of mission	Closed Ionet, TCP/IP
6	EO-1 MOC	TRW Redondo Beach	2	~~Command and~~ Telemetry	256k	Real-time/offline	May 99 L +60 days	Science data TCP/IP Open Ionet
6	EO-1 MOC	TRW Redondo Beach	2	~~Command and~~ Telemetry	56k	Real-time/offline	L+ 60 days to end of mission	Science data TCP/IP Open Ionet
7	EO-1 MOC	MIT LL	2	~~Command and~~ Telemetry	56k		May 99 end of mission	Science data TCP/IP Open Ionet
8	WPS, AGS, SGS ~~EO-1 MOC~~	~~WPS, AGS, SGS~~ EO-1 MOC	1	Tracking data	TBD	FTP	May 99 end of mission	Open Ionet
9	~~EO-1 MOC~~ WPS, AGS, SGS	~~WPS, AGS, SGS~~EO-1 MOC	1	Station Status Brdcst.	TBD		May 99 to end of mission	S and X Band
10	WPS	SAFS	1	State of Health recorder dump	1.8 Gb	in 1 hour	May 99 to end of mission	Open Ionet
11	GSFC SAFS ~~EO-1 MOC~~	~~GSFC SAFS~~ EO-1 MOC	1	State of Health recorder dump	1.8 Gb	in 1 hour	May 99 to end of mission	Open Ionet
12	~~SAFS~~ WPS, AGS, SGS	~~WPS, AGS, SGS~~SAFS	1	Logged downlinked S-Band data~~State of Health recorder dump~~	1.8 Gb	in 1 hour via FTP	May 99 to end of mission	Open Ionet

Table 5 - 2. Data Link Requirements

Item #	From	To	1-Way or 2-Way	Mission Phase	Service Dates(s) and Duration	Purpose and Remarks
1	EO-1 MOC~~occ~~	WPS, SGS, AGS	2	Pre-Launch and normal ops	May 99 thru mission life	Pass coordination
2	EO-1 MOC~~occ~~	WSC	2	Pre-Launch and normal ops	May 99 thru mission life	Pass coordination
3	EO-1 MOC~~occ~~	VAFB	2	Launch	May 99 – Jan 00	Operations net
4	EO-1 MOC~~occ~~	VAFB	2	Launch	May 99 – Jan 00	Management net
5	EO-1 MOC~~occ~~	VAFB	2	Launch	May 99 – Jan 00	Launch operations net
6	EO-1 MOC~~occ~~	VAFB	2	Launch	May 99 – Jan 00	Engineering support

***** CCL's not included in this table *******
***** Closed Circuit TV not included in this requirement**********

Table 5 - 3. Voice Link Requirements

Section 6. Data Processing

6.0 Summary

EO-1 data processing takes place in the MOC. The MOC systems provide the off-line function to process EO-1 scenes. The EO-1 scenes will be processed through radiometric, atmospheric, and geometric correction processes. Paired EO-1/Landsat 7 scenes will then be archived and distributed in the SVF.

The mission operations procedures for data processing and archiving are documented in EO-1 Mission Procedures Document. The requirements for the Data Processing System are~~is~~ documented in the EO-1 Ground Functional and Performance Requirements. Both documents are located on the EO-1 project website:

http://eo1.gsfc.nasa.gov

Section 7. Trajectory and Attitude Support

7.0 Summary

During the first 30-60 days of EO-1 operations, the MOC will perform Flight Dynamics orbit and attitude computations to support the spacecraft as it moves into a Formation Flying configuration with Landsat-7 and is initially operated in that formation. After a successful period of MOC based operations, the operations related to Formation Flying will be transitioned to an onboard autonomous mode using the AUTOCON-F flight software. While onboard control of Formation Flying is prime, the MOC Flight Dynamics Support Subsystem (FDSS) will closely monitor this function. The FDSS in the MOC will continue to provide orbit and attitude product generation and validation of orbit and attitude functions throughout the life of the mission. The FDSS products will be utilized for operational timeline planning by the Mission Operations Planning & Support System (MOPSS), as inputs for various computed commands and table loads and in support of image planning and processing**.**

The FDSS will be hosted on both a personal computer using the Windows NT operating system, as well as, on an HP XXXX workstation each located in the MOC.

The mission operations for the FDSS are documented in the EO-1 Mission Procedures Document. The requirements for the FDSS are documented in the EO-1 Ground Functional and Performance Requirements. Both documents are located on the EO-1 Project website:

http://eo1.gsfc.nasa.gov

~~*7.0 Summary*~~

~~During the first year of operations, the MOC will perform trajectory and orbit determination, and the formation flying with the Landsat spacecraft. In its second year of operations, if approved, EO-1 will perform autonomous orbit determination and maneuver operations utilizing a GPS receiver and the AutoCon flight software. The Flight Dynamics Support Subsystem (FDSS) will be used in the validation of these functions, and computed maneuver commands will be uplinked if the on-board system fails, and before the system is "turned on". The entire "formation flying" process will be closely monitored via the FDSS. The FDSS will also be used to generate ground station~~

~~view periods and other scheduling aids, spacecraft antenna pointing angles, and attitude products for image processing.~~

~~The FDSS will be hosted on a personal computer using and NT operating system and located in the MOC.~~

~~The mission operations procedures for FDS are documented in EO-1 Mission Procedures Document. The requirements for the FDS are documented in the EO-1 Ground Functional and Performance Requirements. Both documents are located on the EO-1 project website:~~

~~http://eo1.gsfc.nasa.gov~~

Appendix A. Glossary

ACS	Attitude Control System
ADS	Attitude Determination System
AGS	Alaska Ground Station
ALI	Advanced Land Imager
AOS_1	Advanced Orbiting System
AOS_2	Acquisition of Signal
APID	Application Identifier
BER	bit error rate
BPSK	Bi-Phase Shift Keying
CADU	Channel Access Data Unit
CCSDS	Consultative Committee for Space Data Systems
CLCW	Command Link Control Word
CMD	Command
CTV	Compatibility Test Van
CVCDU	Coded Virtual Channel Data Unit
D/L	Downlink
DG	Data Group
DMR	Detailed Mission Requirement
DSN	Deep Space Network
DSS	Deep Space Station
EIRP	Effective Isotropic Radiated Power
ETR	Eastern Test Range
EO-1	Earth Orbiter-1
FDF	Flight Dynamic Facility
FDSS	Flight Dynamic Support System
FSW	Flight Software

FTP	File Transfer Protocol
Gbps	Giga bits per second
GDSCC	Goldstone Deep Space Communications Complex
GMT	Greenwich Mean Time
GPS	Global Positioning System
GS	Ground Station
GSFC	Goddard Space Flight Center
H/S	Health and Safety
HK	Housekeeping
HW	Hardware
I&T	Integration and Test
ICD	Interface Control Document
IIRV	Improved Interrange Vector
IP	Internet Protocol
kbps	Kilobits per second
L&EO	Launch and Early Orbit
LAN	Local Area Network
LHCP	Left Hand Circular Polarization
LOS	Loss of signal
LV	Launch Vehicle
LZP	Level Zero Processing
Mbps	Megabits per second
MGS	McMurdo Ground Station
MHz	Million hertz
MOC	Mission Operations Center
MP	Mission Planning
MS	Multi-Spectral
N/A	Not Applicable
NASA	National Aeronautics and Space Administration

NCC	Network Control Center
NISN	NASA Integrated System Network
NMP	New Millennium Program
NORAD	North American Air Defense
PAN	Panchromatic
PM	Phase Modulated
R/T	Real Time
RCS	Reaction Control System
RF	Radio Frequency
RHCP	Right Hand Circular Polarization
RPM	Revolution Per Minute
RS	Reed Solomon
S/A	Solar Array
SAC-C	Satelite de Aplicaciones Cientifica - C
SAFS	Standard Automated File Service
SFDU	Standard Formatted Data Unit
SGS	Spitzbergen Ground Station
SN	Space Network
SOH	State of Health
SSA	S-band Single Access
SSR	Solid State Recorder
SVF	Science Validation Facility
SW	Software
SWIR	Science Wave Infra-Red
TBD	To Be Determined
TBS	To Be Supplied
TC	Telecommand
TCP	Transmission Control Protocol
TDRSS	Tracking and Data Relay Satellite System

TLM	Telemetry
U/L	Uplink
VAFB	Vandenberg Air Force Base
VC	Virtual Channel
VCDU	Virtual Channel Data Unit
WGS	Wallops Ground Station
WOTIS	Wallops Orbital Tracking Information System
WSC	White Sands Complex
WR	Western Range

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R. Harbaugh, Code 581	1
R. Harris, Code 450	1
W. Watson, Code 450	1
R. Stelmaszek, Code 450.3	1
R. Flaherty, Code 451	1
R. Clason, Code 451	1
D. Littmann, Code 451.1	1
B. Gioannini, Code 451.3	1
P. Garza, Code 452.2	1
J. Christo, Code 453.4	1
S. Currier, Code 452	1
R. DeFazio, Code 572	1
G. Fisher, Code 452	1
G. Kientz, Code 241	1
S. Kremer, Code 452	1
R. Stanley, Code 453.4	1
B. Corbin, Code 567	1
R. Chimiak, Code 583	1
Y. Wong, Code 450.4	1
J. Hengemihle	1
J. Braun, ATSC/TSS	1
J. Howard, ATSC	1
A. Kost, ATSC	1
L. McConville, ATSC	1
P. Peskett, ATSC/Wlps	1
R. Rodriguez, ATSC/MMS	1
T. Russell, ATSC/NIA	1